

**02-8 IUTAM Symposium on Reynolds Number
Scaling in Turbulent Flow
Princeton, NJ, USA, 11-13 September 2002**

a) Scientific Committee

A. Smits (USA, Co-Chair), H. Fernholz (Co-Chair),
K.R. Sreenivasan (Co-Chair), P. Bandyopadhyay (USA),
D.M. Bushnell (USA), W.K. George (USA), J. Hunt
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F.T.M. Nieuwstadt (Netherlands), I. Procaccia (Israel),
R.M.C. So (Hong Kong), C. Wark (USA), T. Tatsumi
(Japan, IUTAM repres.)

b) Short summary of scientific progress achieved

The behavior of turbulence at high Reynolds number is interesting from a fundamental point of view, in that most theories of turbulence make very specific predictions in the limit of infinite Reynolds number. From a more practical point of view, there exist many applications that involve turbulent flow where the Reynolds numbers are extremely large. For example, large vehicles such as submarines and commercial transports operate at Reynolds numbers based on length of the order of 10^9 , and industrial pipe flows cover a very wide range of Reynolds numbers up to 10^7 . Many very important applications of high Reynolds number flow pertain to atmospheric and other geophysical flows where extremely high Reynolds numbers are the rule rather than the exception, and the understanding of climate changes and the prediction of destructive weather effects hinges to some extent on our appreciation of high-Reynolds number turbulence behavior.

The important effect of Reynolds number on turbulence has received a great deal of recent attention. The objective of the Symposium was to bring together many of the world's experts in this area to appraise the new experimental results, discuss new scaling laws and turbulence models, and to enhance our mutual understanding of turbulence.

Papers were presented in the following areas: similarity scaling, high Reynolds number asymptotics, isotropic and homogeneous turbulence, simulation and modeling of high Reynolds number flows, control of high Reynolds number flows, and applications of Reynolds number scaling.

The Symposium provided a stimulating forum for scientists from a wide variety of backgrounds, and produced many useful interactions. Although the Symposium started on a somber note (the opening day was the first anniversary of the September 11, 2001 terrorist attacks in the US), there was a friendly and relaxed atmosphere throughout the proceedings, which helped to stimulate intense and productive exchanges.

c) Countries represented and number of participants

Australia (3), Canada (2), England (6), France (2), Germany (8), Israel (1), Italy (1), Japan (18), Netherlands (2), Spain (2), Sweden (8), Taiwan (2), USA (34).

d) Publication of Proceedings of the Symposium

The proceedings will be published by Kluwer Academic Publishers in 2003 (editor: A. J. Smits).

e) Financial supports

The organizers extend their thanks to the following for sponsorship of this IUTAM Symposium:

- . International Union of Theoretical and Applied Mechanics
- . Kluwer Academic Publishers
- . Princeton University

f) Scientific program

Session 1

Invited talks

F.T.M. Nieuwstadt and J.C.R. Hunt, *Characteristics of High-Reynolds Number Turbulence in the Atmosphere*

R.J. Adrian, *Scaling and the relationship to structure*

Oral Presentations

M. Buschmann, M. Gad-el-Hak, *Reynolds-number-dependent scaling law for turbulent boundary layers*

K. Knobloch, H. Fernholz, *Statistics, Correlations, and Scaling in a Canonical, Incompressible Turbulent Boundary Layer with $Re_{\square} < 1.15 \times 10^5$*

I. Marusic, G.J. Kunkel, *Turbulence intensity similarity laws for high Reynolds number boundary layers*

J. Jimenez, J.C. del Alamo, O. Flores, *Large-scale organization of the turbulent wall region*

K. Iwamoto, Y. Suzuki, N. Kasagi, *Nonlinear interaction of coherent structures in wall turbulence at low-to-moderate Reynolds numbers*

H.M. Nagib, C. Christophorou, P. A. Monkewitz, J.M. Österlund, *Higher Reynolds Number Boundary Layer Data on a Flat Plate in the NDF*

Poster Presentations

M. Hayakawa, *Empirical Assessment on the Mean Flow Similarity of Flat Plate Turbulent Boundary Layers*

M.S. Borgas, B.L. Sawford, *Simple Lagrangian models for anomalous high Reynolds number scaling of scalar structure functions*

O. Kitoh, K. Nakabayashi, *Similarity Law of Turbulence Intensity Distribution for Channel Flow*

Session 2

Invited talks

B. Sawford, M. Borgas and P.K. Yeung, *Lagrangian modeling of turbulent diffusion in the atmosphere -- recent developments*

J. Klewicki and M. Metzger, *Studies of high Reynolds number turbulence in the atmospheric surface layer over the salt plain of western Utah*

Oral Presentations

U. Högström, J.C.R. Hunt, A. Smedman, *Theory and measurements for turbulence spectra and variances in the atmospheric neutral surface layer*

M. Oberlack, S. Guenther, *New Scaling Laws of Shear-Free Turbulent Diffusion and Diffusion-Waves*

S.C. Morris, J.F. Foss, *Similarity Scaling of the Transverse Vorticity in a High Reynolds Number Single Stream Shear Layer*

S. de Bruyn Kops, K.B. Winters, J.J. Riley, *Reynolds and Froude Number Scaling in Stably-Stratified Flows*

J.F. Foss, S.C. Morris, M.C. Maher, R.J. Prevost, *Comparative Measures of the Velocity and Vorticity Statistics from High R_λ (300-850) Turbulence Fields: Atmospheric Boundary Layer and a Single Stream Shear Layer*

M. Metzger, J. Klewicki, P. Priyadarshana, *Reynolds number dependencies in the behavior of boundary layer axial stress and scalar variance transport*

Poster presentations

R. Worthington, J.F. Morrison, R.P. Hoxey, *Pressure Fluctuations and Vortical Structures in the Atmospheric Surface Layer*

A. Smedman, U. Högström, J.C.R. Hunt, *Effects of Shear Sheltering in a Slightly Stable Atmospheric Boundary Layer With Strong Shear*

M. Skote, D.S. Henningson, *Reynolds number scaling in separated turbulent boundary layers*

K. Bobba, J.C. Doyle, M. Gharib, *A Reynolds number independent model for turbulence in Couette Flow*

P. Hancock, *Scaling of the near-wall layer beneath reattaching separated flow*

Session 3: Superfluid Helium Minisymposium

Invited Talks

R. Donnelly, *The fundamentals of superfluid helium*

J. Vinen, *Superfluid turbulence: experiments, physical principles, and outstanding problems*

C. Beranghi, *Superfluid turbulence: vortex reconnections and numerical simulations*

Oral Presentations

S. Kida, S. Goto, T. Makihari, *Enhancement of Mixing by Vortex Clusters*

A. Priyadarshana, J.C. Klewicki, *Reynolds number scaling of wall layer velocity-vorticity products*

M. Tsubokura, T. Tamura, *Scaling of the large-scale motions in fully developed turbulent channel flow*

F. Durst, E.S. Zanoun, H. Nagib, *The Mean Velocity Profile of Two-Dimensional Fully-Developed Turbulent Plane-Channel Flows*

Poster Presentations

S. Jung, J. Aubert, C.N. Baroud, H.L. Swinney, *Nonextensivity in turbulence in a rapidly rotating fluid*

S.C. Ling, H.P. Pao, *A unified theory for the origin of turbulence and its subsequent evolution*

R.M. Kerr, *Variance budgets in Rayleigh-Bernard convection*

B. Chabaud, B. Hebral, S. Pietropinto, P.-E. Roche, C. Baudet,

Y. Gagne, C. Poulain, B. Castaing, Y. Ladam, P. Lebrun,

O. Pirotte, *Very high Reynolds number turbulence with low-temperature gaseous helium*

Session 4

Invited talks

C. Meneveau, B. Tao, C. Higgins, J. Katz, M.B. Parlange, *Alignment trends of vectors and tensors in turbulence: from laboratory duct flows to the atmospheric surface layer*

Y. Kaneda, T. Ishihara, *Spectra of Fourth Order Velocity Moments in Homogeneous Isotropic Turbulence: Direct Numerical Simulation and Lagrangian Theory*

Oral Presentations

P.K. Yeung, S. Xu, M.S. Borgas, B.L. Sawford, *Scaling of multi-particle Lagrangian statistics in Direct Numerical Simulations*

R.D. Moser, P. Zandonade, *Development of High Reynolds Number Optimal LES Models*

Y. Tsuji, *Similarity Scaling and Statistics of Pressure Fluctuation*

T. Nakano, T. Gotoh, *Convection, Pressure and Dissipation in Three-Dimensional Turbulence*

A. Gutierrez Rubino, J.F. Morrison, R.P. Hoxey, A.J. Smits, *A Quantitative Estimate of 'Inactive' Motion*

Poster presentations

N. Rimbert, O. Séro-Guillaume, *Dependence of Levy Statistics with Reynolds Number*

L. Castillo, X. Wang, *The Asymptotic Profiles in Forced Convection Turbulent Boundary Layers*

L. Castillo, R.B. Cal, *Scaling of Turbulent Boundary Layers With Suction and Blowing*

B. Lindgren, Y. Tsuji, A.V. Johansson, *Universality of Probability Density Distributions in the Log-Layer in High Reynolds Number Turbulent Boundary Layers*

J.G. Brasseur, C. Johansson, A. Smedman, U. Hogstrom, *Similarity Structure of the Convective Boundary Layer Analyzed with Combined Large-eddy Simulation and Experimental Data*

R. Lindken, J. Westerweel, F.T.M. Nieuwstadt, *A micro-PIV system for measurements in a high Reynolds number wind tunnel at 200 bar*

Session 5

Invited talks

I. Procaccio, *Anisotropy in Turbulence: Universal Exponents in the Restoration of Isotropy*

V. Yakhot, *Reynolds number scaling of Large Eddy Simulations of strongly non-linear fluids*

Oral Presentations

F. Toschi, A. Lanotte, L. Biferale, *Homogeneous and non-isotropic, stationary and decaying turbulence*

T. Miyauchi, M. Tanahashi, S. Iwase, *Coherent fine scale eddies and energy dissipation rate in homogeneous isotropic turbulence up to $Re_\lambda = 220$*

L.J. Jiang, T. S. Yang, S.S. Shy, *Four-Dimensional Measurements of The Structure of Dissipative Scales in An Aqueous Near-Isotropic Turbulence*

E. Villermaux, *Random mixing, space dimension, and Reynolds number*

W.K. George, H. Wang, *The spectral transfer in isotropic turbulence*

B.R. Pearson, P.A. Krogstad, G.R. Johnson, *Re dependence of the Kolmogorov constant and scaling*

Poster Presentations

H. Miura, *Suppression of vortical motions by acoustic waves in weakly compressible decaying isotropic turbulence*

J. Lewalle, *Analytical approach to intermittency and scaling in finite Re incompressible turbulence*

J. Cleve, T. Dziekan, M. Greiner, *Reynolds number dependence of the intermittency exponent in fully-developed turbulence*

T.S. Yang, S.S. Shy, *A Gas-Phase Near-Isotropic Turbulence and Its Wavelet Analysis for Studying Fine-Scale Intermittency*

B. Eckhardt, J. Schumacher, A. Jachens, R. Pandit, *Derivative moments and correlations in homogeneous shear flows*

Session 6

Invited talks

A. Johansson, B. Lindgren, J.M. Osterlund, *Mean Profile and Two-Point Correlation Distribution Laws in the Outer Region of High Re Turbulent Boundary Layers –Symmetry Methods in the Light of Experimental Data*

K. Sreenivasan, *Reynolds and Schmidt number scaling from experiment and simulations*

Oral Presentations

B.J. McKeon, J.F. Morrison, W. Jiang, J. Li , A.J. Smits, *Additional measurements and analysis of high Reynolds number fully-developed turbulent pipe flow*

M.B. Jones, N. Nishizawa , M.S. Chong, I. Marusic, *Scaling of the turbulent boundary layer at high Reynolds numbers*

R. Abstiens, W. Schröder, W. Limberg, *Hot-wire measurements of two point correlations in the flat plate boundary layer at high Reynolds numbers*

M. Wosnik, T.G. Johansson, *On the experimental sorting of competing theories for wall-bounded turbulent flows*

Y. Nagano, T. Houra, *Scaling of Near-Wall Structures in Turbulent Boundary Layers Subjected to Adverse Pressure Gradient*

Poster presentations

S. Mochizuki, H. Osaka, T. Kameda, *An experimental study of a self-preserving boundary layer with a power-law variation of free-stream velocity*

T. Buffin-Bélanger, A.G. Roy, *The effects of the Reynolds number on the turbulent flow structure around pebble clusters in a gravel-bed river*

W. Brewer, *Investigating Reynolds scaling of tip-leakage vortex flow via unstructured RANS simulations*

V.J. Kaku, M.C. Boufadel, A.D. Venosa, *Evaluation of Mixing Energy in the Swirling and Baffled Flasks*

J. Park, C. Henoch, K.S. Breuer, *Drag Reduction in Turbulent Flows using Lorentz Force Actuation*

C.H. Bruneau, H. Kellay, *Coexistence of two cascades in two-dimensional turbulence*

Report composed by Alexander J. Smits